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REPORT

ON

LAKE BUCHANAN

BURNET AND LLANO COUNTIES

TEXAS

EPA REGION VI

WORKING PAPER NO. 636

WITH THE COOPERATION OF THE

TEXAS WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

FEBRUARY, 1977

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16. ABSTRACT:

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass

LAKE BUCHANAN

LAKE BUCHANAN

STORET NO. 4806

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Bucha an is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the lake. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this lake.

Lake Buchanan ranked twenty-fifth in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Nineteen of the water bodies had less and one had the same median total phosphorus, 22 had less and two had the same median dissolved phosphorus, 29 had less and two had the same median inorganic nitrogen, 14 had less mean chlorophyll a, and ten had greater mean Secchi disc transparency. Hypolimnetic dissolved oxygen was depleted at station 1 in May and August and at station 2 in August; marked depression of dissolved oxygen occurred at station 3 in May and August.

Survey limnologists noted macrophytes in the shoreline shallows near stations 1, 2, and 3.

* See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate Lake Buchanan was phosphorus-limited at the times the assay samples were collected (03/14/74 and 11/04/74).

The lake data indicate phosphorus limitation at all sampling stations and times.

C. Nutrient Controllability:

1. Point sources--It is estimated that point sources, including septic tanks, contributed less than 1% of the total phosphorus load to the lake.

During the sampling year, Lake Buchanan received a total phosphorus loading almost twice that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). However, even if Vollenweider's eutrophic level is applicable to Texas reservoirs, it does not seem likely that elimination of the point-source phosphorus would result in significant improvement in the trophic condition of the lake.

2. Non-point sources--It is calculated that non-point sources contributed essentially all of the phosphorus input to the lake during the sampling year with the Colorado River providing about 95% of the total load.

The phosphorus export rates of the tributaries of Lake Buchanan were quite low during the sampling year (see page 12) and compare well with the exports of the tributaries of downstream Lake Lyndon B. Johnson* (range of -1 to 2 kg/km^2/yr).

* Working Paper No. 645.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 93.19 kilometers^2.
2. Mean depth: 13.1 meters.
3. Maximum depth: 40.2 meters.
4. Volume: 1,222,492 x 10^6 m^3.
5. Mean hydraulic retention time: 1.7 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Colorado River	79,603.6	22.890
Calvert Creek	7.9	0.015
Fall Creek	132.1	0.289
Cherokee Creek	461.0	1.060
N. Fork Morgan Creek	46.6	0.099
Minor tributaries & immediate drainage -	593.5	2.660
Totals	80,844.1	27.013

2. Outlet -

Colorado River	80,937.4**	23.070**

C. Precipitation***:

1. Year of sampling: 98.2 centimeters.
2. Mean annual: 75.7 centimeters.

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† Table of metric conversions--Appendix B.
†† Latchford, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1971-1976".
** Includes area of lake; lesser outflow due to evaporation (Yost, 1976).
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Buchanan was sampled four times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake and from two or more depths at each station (see map, page vi). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 15.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 30.8 meters at station 1, 19.5 meters at station 2, 15.8 meters at station 3, and 3.7 meters at station 4.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not preserved properly and were not analyzed).

A SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE BLOCKHOUSE STUDY CODE 4035

1ST SAMPLING : 3/24/76

4 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	10.3 - 15.6	13.3	13.7
DISS OXY (MG/L)	5.6 - 10.2	8.7	9.0
CNDCTVY (MICROMO)	525. - 672.	610.	590.
PH (STAND UNITS)	8.0 - 8.5	8.3	8.4
TOT ALK (MG/L)	248. - 283.	261.	265.
TOT P (MG/L)	0.013 - 0.046	0.028	0.030
DIS P (MG/L)	0.003 - 0.027	0.014	0.014
NO2+NO3 (MG/L)	0.211 - 0.240	0.223	0.225
AMMONIA (MG/L)	0.028 - 0.106	0.064	0.036
KJEL N (MG/L)	0.383 - 0.488	0.444	0.468
INORG N (MG/L)	0.248 - 0.276	0.254	0.255
TOTAL N (MG/L)	0.648 - 0.988	0.698	0.685
CHLOPHYL A (UG/L)	4.2 - 8.4	6.4	6.5
SECCHI (METERS)	2.4 - 2.1	1.6	1.5

2ND SAMPLING : 5/25/76

4 SITES

RANGE	MEAN	MEDIAN
24.6 - 28.4	25.3	24.2
6.8 - 6.8	6.3	5.1
567. - 621.	598.	722.
7.5 - 8.6	8.2	8.3
248. - 254.	249.	248.
0.015 - 0.191	0.052	0.040
0.009 - 0.032	0.021	0.021
0.248 - 0.284	0.279	0.278
0.248 - 0.238	0.273	0.258
0.288 - 1.188	0.482	0.482
0.128 - 0.518	0.251	0.215
0.248 - 1.488	0.666	0.558
7.3 - 18.3	9.2	9.8
8.3 - 2.9	1.8	1.8

3RD SAMPLING : 8/25/76

4 SITES

RANGE	MEAN	MEDIAN
26.5 - 28.7	25.6	25.8
6.8 - 7.8	6.4	6.8
625. - 688.	702.	788.
7.5 - 8.7	8.2	8.3
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		
4.5 - 26.8	12.8	7.8
8.8 - 4.3	2.6	2.8

[illegible] SUMMARY OF [illegible] AND CHEMICAL CHARACTERISTICS for LAKE [illegible]
STUDY CODE [illegible]

[illegible] SAMPLING [illegible]

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	24.5 - 28.7	25.-	25.0
DISS OXY (MG/L)	6.2 - 8.8	7.0	7.0
CNDUCTVY (MICROMO)	573. - 595.	584.	582.
PH (STAND UNITS)	7.7 - 8.1	8.0	8.0
TOT ALK (MG/L)	124. - 128.	126.	127.
TOT P (MG/L)	0.031 - 0.172	0.077	0.058
DFLAG P (MG/L)	0.011 - 0.075	0.027	0.020
ORTHO (MG/L)	0.018 - 0.046	0.024	0.020
AMMONIA (MG/L)	0.029 - 0.108	0.047	0.040
TOT N (MG/L)	0.780 - 1.080	0.940	0.880
NO3NO2 N (MG/L)	0.230 - 0.590	0.345	0.290
TOTAL N (MG/L)	0.410 - 1.480	0.694	0.735
CHLOPYL A (UG/L)	2.3 - 18.	7.2	5.0
SECCHI (METERS)	0.2 - 1.5	1.0	0.7

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Algal Units per ml
03/14/74	1. Chroomonas sp.	1,482
	2. Scenedesmus sp.	1,104
	3. Nitzschia sp.	680
	4. Centric diatoms	640
	5. Cryptomonas sp.	641
	Other genera	1,928
	Total	6,966
05/21/74	1. Tetraedron sp.	453
	2. Scenedesmus sp.	316
	3. Chroomonas sp.	272
	4. Cryptomonas sp.	181
	5. Nitzschia sp.	181
	Other genera	647
	Total	2,050
11/04/74	1. Flagellates	990
	2. Stephanodiscus sp.	186
	3. Ankistrodesmus sp.	124
	4. Cryptomonas sp.	124
	5. Scenedesmus sp.	124
	Other genera	493
	Total	2,041

* The August phytoplankton sample was lost in shipment

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/14/74	1	6.4
	2	5.2
	3	6.6
	4	8.4
05/21/74	1	9.9
	2	10.1
	3	7.0
	4	9.8
08/16/74	1	4.5
	2	6.0
	3	8.8
	4	24.9
11/04/74	1	2.3
	2	6.4
	3	16.5
	4	3.7

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.280	0.1
0.050 P	<0.055	0.280	6.2
0.050 P + 1.0 N	<0.055	1.280	15.5
1.0 N	<0.005	1.280	0.1

b. November sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.366	2.7
0.050 P	0.060	0.366	8.0
0.050 P + 1.0 N	0.060	1.366	17.6
1.0 N	0.010	1.366	2.7

E. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Lake Buchanan was low in March but moderately high in November. The results also indicate that Lake Buchanan was phosphorus limited both times. Note that the addition of orthophosphorus alone or in combination with nitrogen resulted in significantly increased yields, but the addition of nitrogen alone did not.

The lake data also indicate phosphorus limitation at all sampling times; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 16/1 or greater at all sampling stations and times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km²/year, at stations A-2, B-1, C-1, D-1, and E-1 and multiplying the means by the ZZ area in km².

The operator of the Silver Creek Lodge wastewater treatment plant did not participate, and nutrient loads were estimated at 1.134 P and 3.401 kg N/capita/year.

* See Working Paper No. 175.

A. Waste Sources*:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Silver Creek Lodge	30	aer. pkg. plant	15.1	Lake Buchanan

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Colorado River	6,320	95.1
Calvert Creek	5	<0.1
Fall Creek	120	0.1
Cherokee Creek	1,665	1.7
N. Fork Morgan Creek	35	<0.1
b. Minor tributaries & immediate drainage (non-point load) -	830	0.9
c. Known municipal STP's -		
Silver Creek Lodge	35	<0.1
d. Septic tanks** -	325	0.4
e. Known industrial - None	-	-
f. Direct precipitation*** -	1,635	1.8
Total	91,870	100.0

2. Outputs -

Lake outlet - Colorado River 15,995

3. Net annual P accumulation - 75,875 kg.

* Andrews, 1976; Wyatt, 1976.
** Estimate based on 1,143 lakeshore dwellings; see Working Paper No. 175.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Colorado River	1,431,660	89.7
Calvert Creek	95	<0.1
Fall Creek	4,705	0.3
Cherokee Creek	23,930	1.5
N. Fork Morgan Creek	2,405	0.1
b. Minor tributaries & immediate drainage (non-point load) -	20,300	1.3
c. Known municipal STP's -		
Silver Creek Lodge	100	<0.1
d. Septic tanks* -	12,180	0.8
e. Known industrial - None	-	-
f. Direct precipitation** -	100,750	6.3
Total	1,596,125	100.0

2. Outputs -

Lake outlet - Colorado River 660,840

3. Net annual N accumulation - 935,285 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Colorado River	1	18
Calvert Creek	<1	13
Fall Creek	<1	36
Cherokee Creek	3	52
N. Fork Morgan Creek	<1	52

* Estimate based on 1,143 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
S. Fork Morgan Creek	0.011	1.107

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	0.98	0.81	17.1	10.0

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of Lake Buchanan:

"Dangerous" (eutrophic loading)	0.54
"Permissible" (oligotrophic loading)	0.27

V. LITERATURE REVIEWED

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Yost, I. D., 1976. Personal communication (total inflows and outflows of Lake Buchanan). U.S. Geol. Surv., Austin.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE CODE	LAKE NAME	[illegible] TOTAL *	[illegible] [illegible] *	[illegible] [illegible] FEET	[illegible] [illegible]	[illegible] [illegible]	[illegible] 1000 [illegible] *
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible] LAKE

[illegible] DATA TABLE [illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL *	[illegible] [illegible] %	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible] *
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

| | | |

[illegible] OF LAKES WITH [illegible] VALUES [illegible] OF LAKES WITH [illegible] VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL N	[illegible] INORG N	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	29 (11)	58 (23)	24 (9)	2 (1)	67 (25)	38 (18)	269
[illegible]	[illegible]	18 (7)	47 (19)	5 (2)	10 (7)	62 (23)	39 (14)	259
[illegible]	[illegible]	85 (33)	37 (14)	87 (33)	42 (16)	17 (6)	54 (19)	372
[illegible]	[illegible]	32 (12)	78 (28)	37 (14)	21 (8)	63 (24)	36 (13)	254
[illegible]	[illegible]	11 (4)	74 (14)	13 (5)	16 (6)	72 (27)	12 (5)	178
[illegible]	[illegible]	39 (14)	34 (13)	61 (23)	45 (17)	17 (8)	21 (7)	217
[illegible]	[illegible]	88 (33)	21 (7)	42 (15)	82 (31)	17 (6)	34 (12)	284
[illegible]	[illegible]	8 (3)	61 (22)	11 (4)	5 (2)	42 (15)	8 (3)	166
[illegible]	[illegible]	54 (20)	22 (7)	58 (22)	61 (23)	46 (17)	63 (23)	311
[illegible]	[illegible]	84 (32)	61 (23)	39 (24)	65 (24)	17 (6)	63 (23)	346
[illegible]	[illegible]	63 (24)	51 (19)	74 (28)	71 (27)	17 (6)	79 (29)	357

| | | |

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	[illegible]	LYNDA V JOHNSON LAKE	234
30	[illegible]	TEXANA LAKE	217
31	[illegible]	SOMERVILLE LAKE	200
32	[illegible]	SAN ANGELO RESERVOIR	197
33	[illegible]	TEXARKANA LAKE	176
34	[illegible]	GARZA LITTLE ELM RESERVO	173
35	[illegible]	TEXOMA	164
36	[illegible]	BRYANS LAKE	159
37	[illegible]	CORPUS CHRISTI LAKE	155
38	[illegible]	HOUSTON LAKE	139
39	[illegible]	LIVINGSTON LAKE	93

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	00065 GAGE HEIGHT	32217 CHLOROPHYLL A	00631 [illegible]
FROM TO	OF DAY	FEET	MICROMOL	UG/L	PERCENT
[illegible]	10	15	[illegible]	[illegible]	
	10	15	[illegible]		
	10	15	[illegible]		
	10	15	[illegible]		
	10	15	[illegible]		
[illegible]	10	05	[illegible]	[illegible]	
	10	05	[illegible]		
	10	05	[illegible]		
	10	05	[illegible]		
	10	05	[illegible]		
	10	05	[illegible]		
[illegible]	15	00	[illegible]		
	15	00	[illegible]		[illegible]
	15	09	[illegible]		[illegible]
[illegible]	12	05	[illegible]	[illegible]	
	12	05	[illegible]		
	12	05	[illegible]		[illegible]
	12	05	[illegible]		
	12	05	[illegible]		
	12	05	[illegible]		
	12	05	[illegible]		

DATE	TIME OF DAY	DEPTH FEET										
04/03/24	13 40	4488	16.2		50	442	6.30	153	0.028	0.480	0.160	0.895
	13 40	8865	17.2	4.4		643	5.90	151	0.024	0.568	0.178	0.818
	13 40	9035	18.2	4.4		662	6.30	156	0.025	0.488	0.190	0.896
	13 40	8633	14.9	4.3		582	6.20	148	0.028	0.488	0.225	0.884
	13 40	8842	14.1	5.6		580	6.10	147	0.040	0.495	0.244	0.816
04/05/21	10 38	8889	24.1		40	786	6.96	141	0.050	0.788	0.266	0.813
	10 38	8885	26.3	6.6		786	6.55	141	0.050	0.488	0.268	0.818
	10 38	8815	25.8	6.8		781	6.50	141	0.056	0.435	0.266	0.811
	10 38	8836	25.7	6.6		776	7.66	140	0.060	0.380	0.246	0.812
	10 38	8849	23.6	6.6		784	7.75	142	0.066	0.405	0.278	0.813
	10 38	8846	26.3	6.2		668	7.72	140	0.070	0.488	0.265	0.819
04/08/15	14 28	8888	24.2	7.8	78	619	8.70					
	14 28	8815	26.8	8.8		621	8.80					
	14 28	8838	27.5	3.8		796	8.25					
	14 28	8840	26.7	3.8		788	7.95					
04/13/04	11 40	8888	28.5	7.4	32	538	6.61	129	0.055	0.588	0.260	0.824
	11 47	8895	28.6	6.9		548	6.85	129	0.070	0.588	0.365	0.825
	11 48	8828	28.6	7.2		536	6.83	126	0.070	0.588	0.368	0.836
	11 48	8835	28.5	7.8		539	6.81	126	0.060	0.588	0.365	0.821
	11 48	8852	28.4	8.2		523	7.71	128	0.168	0.488	0.448	0.822

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF			A	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	13	40	[illegible]	[illegible]	[illegible]
	13	40	[illegible]	[illegible]	
	13	40	[illegible]	[illegible]	
	13	40	[illegible]	[illegible]	
	13	40	[illegible]	[illegible]	
[illegible]	10	30	[illegible]	[illegible]	
	10	30	[illegible]	[illegible]	
	10	30	[illegible]	[illegible]	
	10	30	[illegible]	[illegible]	
	10	30	[illegible]	[illegible]	
	10	30	[illegible]	[illegible]	
[illegible]	14	20	[illegible]	[illegible]	
	14	20	[illegible]		[illegible]
	14	20	[illegible]		[illegible]
[illegible]	11	40	[illegible]	[illegible]	[illegible]
	11	40	[illegible]		[illegible]
	11	40	[illegible]	[illegible]	
	11	40	[illegible]	[illegible]	
	11	40	[illegible]	[illegible]	
	11	40	[illegible]	[illegible]	

[illegible]

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX E

TRIBUTARY DATA

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
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[illegible]							
[illegible]							
[illegible]							
[illegible]							

[illegible]

[illegible]

[illegible]

[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/04/07	13	48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/13/07	12	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/11/07	12	08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/12/07	12	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/01/07	12	48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/22/07	11	58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/13/07	12	03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/04/07	11	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/04/21	11	58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/05/05	12	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/05/1x	18	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/26/07	12	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/07/07	11	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7x/29/07	12	4x	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* [illegible]
[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PROP	OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
04/09/87	13	15	0.396	0.293	0.610	0.016	0.331
04/10/87	12	45	1.469	0.1504	3.015	1.857*	0.010*
04/11/87	12	25	1.894	0.395	0.629	1.017	0.018
04/12/87	12	70	0.360	0.388	1.016	1.305	0.010*
05/11/87	12	36	0.384	0.254	1.535	1.087*	0.010*
05/12/87	12	15	0.224	0.1484	1.004*	0.1004	0.331
05/13/87	12	70	0.230	0.212	0.611	0.1054	0.010*
05/14/87	12	45	1.337	0.710	1.435	0.885	0.036
05/14/21	12	35	1.368	0.158	2.816	0.0854	0.321
05/05/85	13	17	0.360	0.788	0.823	1.0854	0.016
05/05/15	11	05	0.250	0.188	1.885*	0.0854	0.010*
05/06/87	12	33	0.230	0.246	0.810	0.1054	0.010*
05/07/87	14	05	0.236	0.336	0.885*	0.0854	0.010*
05/04/87	13	25	0.294	0.710	0.710	0.1054	0.011

< VALUE KNOWN TO BE
LESS THAN INDICATED

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TU	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7W/09/87	15	20		0.812	0.438	0.338	0.885	0.835
7W/10/87	14	25		0.837	0.388	1.094	0.8259	0.828
7W/11/87	14	30		0.832	0.480	1.025	0.818	0.825
7W/12/87	14	38		0.814	0.288	0.814	0.8854	0.8189
7W/01/87	14	10		0.695	0.705	1.1589	0.8979	0.8139
7W/02/87	13	38		0.784	0.456	0.831	0.844	0.874
7W/03/87	14	25		0.248	0.258	0.811	0.8874	0.825
7W/04/87	13	58		0.845	0.458	0.855	0.885	0.8139
7W/04/21	14	42		0.828	0.328	0.835	0.8859	0.844
7W/05/85	15	02		0.548	2.488	0.126	0.188	0.485
7W/05/21	17	44		0.834	0.788	0.885	0.8854	0.845
7W/06/87	15	18		0.478	1.458	0.817	0.818	0.844
7W/07/87	15	35		0.825	0.458	0.8854	0.8854	0.859
7W/08/87	15	38		0.818	0.458	0.818	0.825	0.875

* VALUE [illegible] TO BE
LESS THAN INDICATED

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	%	TOTAL	[illegible]	
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L *	MG/L *
[illegible]							

* VALUE KNOWN TO BE LESS THAN INDICATED

[illegible]

[illegible]

[illegible]							
[illegible]							
[illegible]							
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1 VALUE TAKEN TO BE LESS THAN INDICATED